

Sheet Metal

AS AN AREA OF

**INDUSTRIAL ARTS INSTRUCTION IN
PENNSYLVANIA PUBLIC SCHOOLS**

SUBJECT AREAS

Automotive	Metal Machining
Ceramics	Planning
Electricity	Plastics
Graphic Arts	Sheet Metal
Home Mechanics	Textiles
Metal Forming	Woodworking



Bulletin 331J • 1953

COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF PUBLIC INSTRUCTION • Harrisburg



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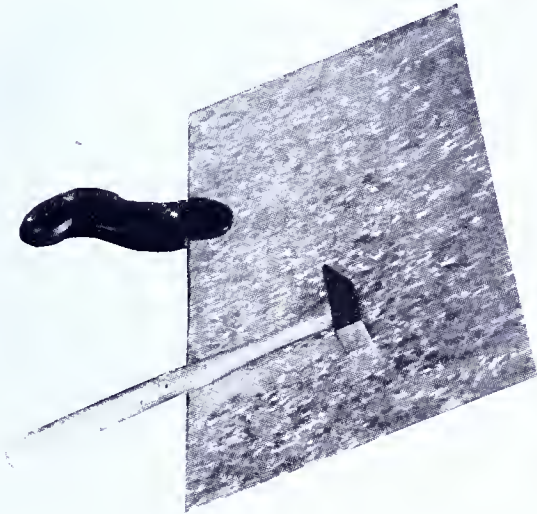
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Foreword_____



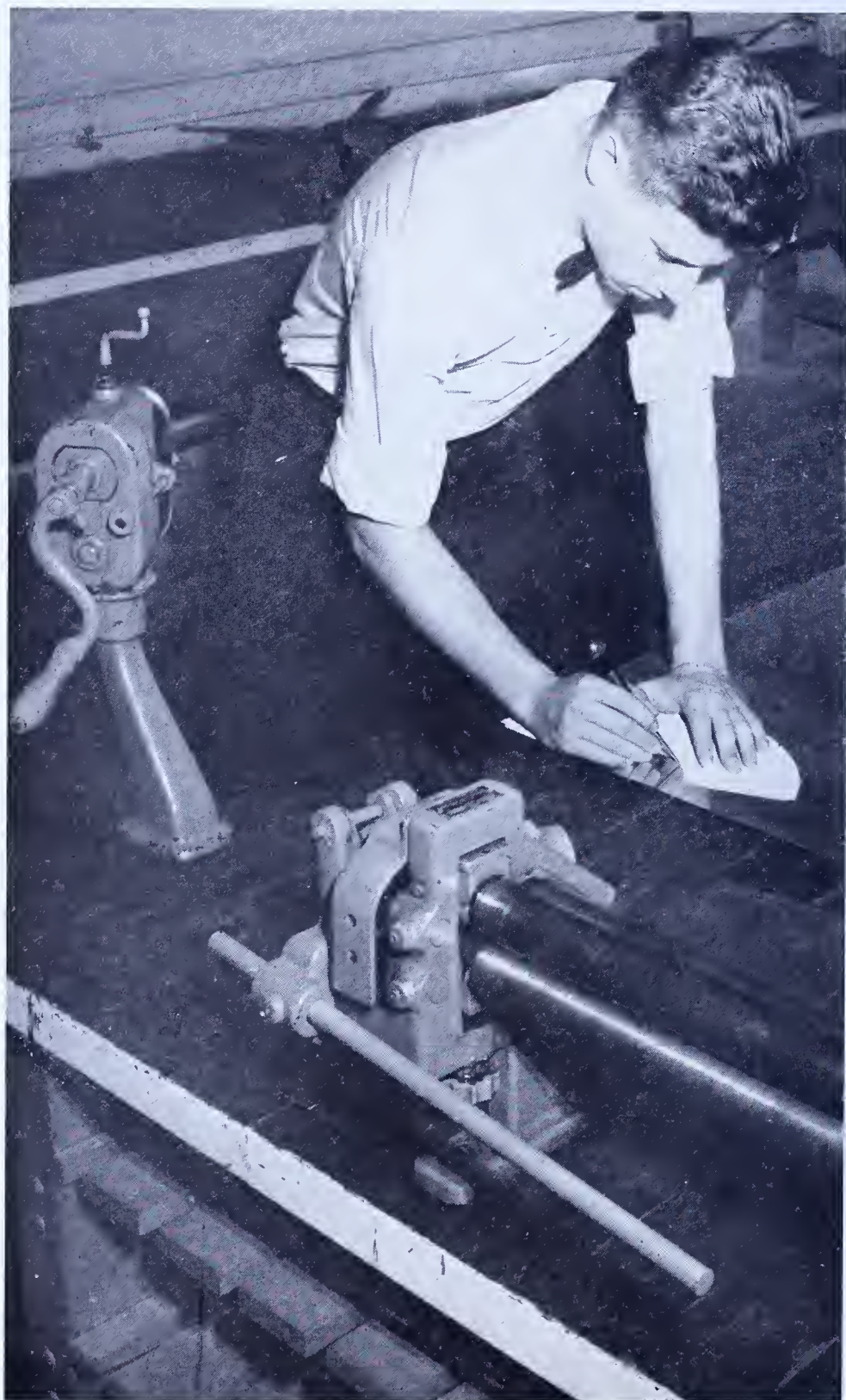
SHEET METAL is one of a series of bulletins prepared to stimulate specific areas of instruction in the broad field of Industrial Arts Education. It is a supplement to *Industrial Arts in Pennsylvania*, Bulletin 331, published in September of 1951 by the Department of Public Instruction.

SHEET METAL was prepared by Ralph D. Widdowson, Area Coordinator of Trade and Industrial Education under the supervision of Robert T. Stoner, Chief, Trade and Industrial Education, and under the general direction and guidance of Paul L. Cressman, Director of the Bureau of Instruction. Preliminary work on manuscript and the layout planning were done by R. Randolph Karch, Adviser, Trade and Industrial Education. Photographs are the work of Lyle Weissenfluh, Adviser, Trade and Industrial Education.

This bulletin has been edited by Rachel S. Turner, Editor for the Department of Public Instruction.

Francis B. Hoar
Superintendent of Public Instruction

February 1953



Department of Public Instruction

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Introduction _____



BECAUSE of the differences in educational concepts, in backgrounds of the administrator and teacher, in variations in the time pupils spend in the activity, in amount of funds available for equipment and supplies, as well as in other factors, no attempt is made in this bulletin to set up a common course of study applicable to all situations, or to tell the teacher what to teach, how to teach, or what equipment he should have in his shop.

This bulletin does list, in the "The Things to Do" and "Things to Know" sections on pages 5 through 10, course content which may be selected by the teacher. These learning units also help to determine particular aims and objectives, amount of time available to pupils in the sheet metal area, and the necessary equipment.

Suggestions to guide the administrator are made on the organization of instruction, instructional material, tools and devices, possible projects, sample project assignments, and the use of records and forms. Included for further guidance are a selected annotated bibliography of readily available instructional materials and visual aids, a suggested inventory of equipment and supplies, their approximate cost, a feasible shop layout, and other information related to establishing or enriching the sheet metal unit of a comprehensive general shop, or a unit (one activity) shop.

Matters pertaining to Industrial Arts in general are not discussed in this bulletin. For further information the reader is referred to Bulletin 331, *Industrial Arts in Pennsylvania*, published by the Department of Public Instruction, September 1951.



1 Sheet Metal

AS A SCHOOL SUBJECT



TO MEET TODAY'S NEEDS, Sheet Metal as a course has been greatly enriched. It is the purpose of this bulletin not only to outline methods of instruction, but also to suggest plans and materials for a well-organized shop.

Aims and Objectives

The aims and objectives of Industrial Arts Education are fully covered on pages 15 through 38 in Bulletin 331, *Industrial Arts in Pennsylvania*, published by the State Department of Public Instruction in 1951. In addition to these aims and objectives of a general nature, the specific aims and objectives of Sheet Metal in the Industrial Arts program include:

1. Understanding the contributions of Sheet Metal to industry and business
2. Providing a background of knowledge and fundamental skills leading to the selection of an avocational interest
3. Knowing the facts concerning the many occupations in the Sheet Metal field to aid in choosing a vocation

4. Recognizing and appreciating good design and workmanship in Sheet Metal
5. Obtaining skills and knowledge for the improvement and maintenance of a home

Sheet Metal as an Integral Part of a Comprehensive General Industrial Arts Shop

This bulletin concerns Sheet Metal as an integral part of at least four activities in a comprehensive general industrial arts shop. The suggested list of supplies, tools, and equipment given in this bulletin is based on the minimum amounts generally accepted for the instruction of five pupils. In local situations where it is necessary to establish a larger unit, the amounts can be proportionately increased to meet the varying situations.

Machines, Tools, Equipment, and Materials

Intelligent planning of the equipment and physical layout of the shop plays a major part in establishing a good Industrial Arts program. In some instances school administrators and school board members, who are not familiar with the many details involved in planning and buying the machines, tools, and equipment for an effective program, should seek the advice of professionally trained industrial arts personnel. If it is possible, a certificated Industrial Arts instructor should be employed in advance to supervise the purchase of equipment and to plan the shop layout. Whether the machines and equipment will be used for junior, junior-senior, or senior high school instruction determines the type and size. The purchase of too small or too light machinery and equipment is false economy, as the maintenance cost over a period of time usually becomes very expensive and will equal or exceed the original purchase price of heavier and more costly equipment. The maximum size of material to be processed in the instruction program and the fact that machines and equipment will be used by unskilled learners should also be considered in deciding the specifications of Sheet Metal machinery. Shop planning and shop layout are covered extensively on pages 95 through 112 in Bulletin 331, *Industrial Arts in Pennsylvania*, published by the State Department of Public Instruction in 1951.

The Area Coordinator of Trade and Industrial Education responsible for the supervision of Industrial Arts in each local school district can be consulted for technical advice.

Use of Materials

A wide variety of materials should be used to meet the broad objectives of Industrial Arts and to provide the pupil with the media for desirable and needed experiences.

The most commonly used metals in Industrial Arts sheet metal are "tin" (tin-plated steel) and galvanized iron. However, there is no justifiable reason for limiting instruction to these two metals. The teacher who limits his course to these materials loses the opportunity to arouse interest in the aesthetic elements of design and the finer aspects of craftsmanship that can be obtained from the use of many other available metals.

A small piece of copper, costing only a few cents, can be used to make a well-designed dish or tray which will be treasured by the mother or sister of the pupil. Aluminum lends itself very well to small, useful, and inexpensive projects. Hence, materials other than "tin" and galvanized iron are listed in the learning units on pages 5 to 10.

When selecting projects consideration should be given to the use of a variety of materials and operations by combining the activities and materials of two or more areas in the comprehensive general shop. For example, where electricity and sheet metal are included, an electric motor project would combine the two activities.

Sheet Metal as a General Unit Shop

In school systems where the enrollment is large enough to justify an Industrial Arts program organized on the unit shop basis, the suggested list of machines, tools, equipment and consumable supplies on pages 36 to 39 can be increased proportionately to establish a unit sheet metal shop. The size and type of machines and equipment should be determined by the planned course of study.

2 Learning Units_____

THINGS TO DO



THE LEARNING UNITS listed on the following pages will suggest to the teacher of sheet metal what his pupils should do and what they should know. These units are invaluable in planning a course of study to meet the objectives of the sheet metal area of the comprehensive general shop.

The material is divided into two parts: THINGS TO DO IN ALL GRADES and THINGS TO DO IN SENIOR HIGH SCHOOL.

Things to Do In All Grades

1. Read a working drawing
2. Make out a bill of material
3. Make a dimensioned sketch.

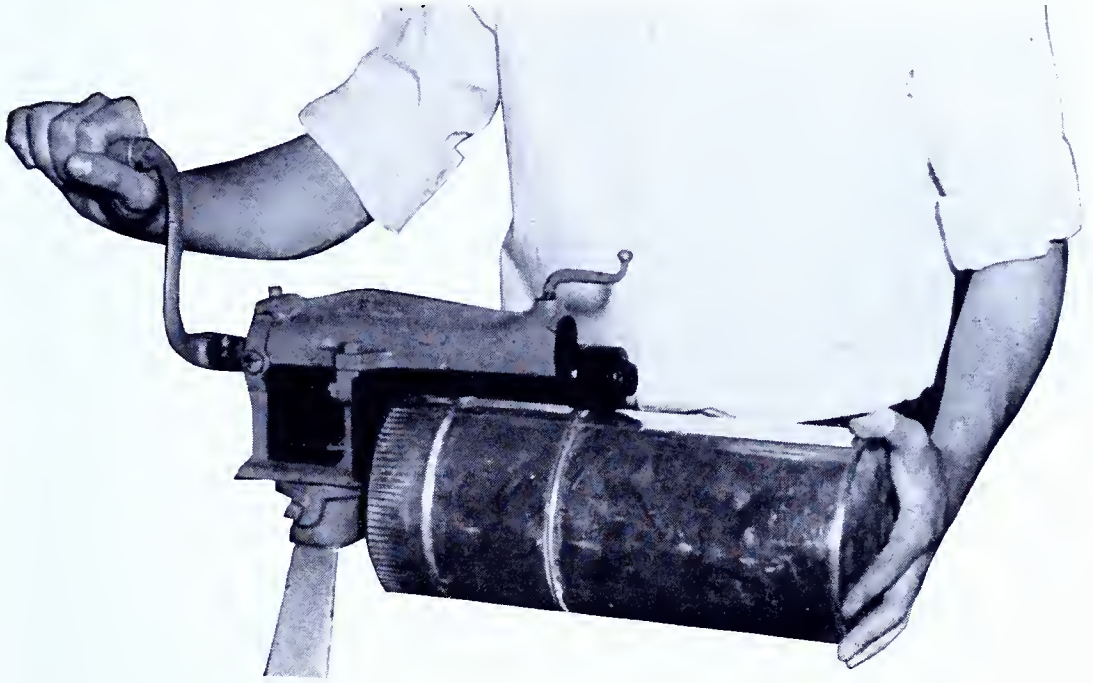
4. Plan the procedure for doing the job
5. Transfer patterns to sheet metal
6. Cut out patterns using straight and curved snips
7. Form by hand
8. Bend with bar folder
9. Form or shape a piece of metal over a stake with a mallet or set hammer
10. Form a cylinder on the slip roll former
11. Light and operate a blowtorch or furnace
12. Tin a soldering copper
13. Solder tin plate, galvanized iron, copper, and brass
14. Turn edges for a hem
15. Make a single and double hem by hand and on a machine
16. Wire the edge of a straight piece with a bar folder and a hammer
17. Make a grooved seam with a hand groover
18. Wire edges on a wiring machine
19. Form with a squaring stake
20. Use the hatchet stake in forming
21. Form with a blowhorn stake
22. Sweat a joint
23. Wire a cone-shaped object on the wiring machine
24. Punch holes with a solid punch
25. Punch holes with a hollow punch
26. Countersink by hand
27. Rivet sheet metal by hand and by using a rivet set
28. Raise or bump sheet metal forms
29. Bend, twist, and form wire
30. Bead with a machine
31. Crimp or shrink edges
32. Develop section patterns for rectangular objects
33. Develop patterns for right-cylinder object
34. Make a double seam
35. Make a bottom double seam
36. Make a simple parallel line development
37. Make a simple radial line development
38. Prepare cut acid flux
39. Clean copper with acid
40. Cut with a hacksaw
41. Cut with a jeweler's saw
42. Drill holes by hand and with drill press

Things to Do In Senior High School

1. Copy from a template
2. Cut sheet metal with the following types of snips: straight, right-hand cut, left-hand cut, aviation; also with squaring shears and bench shears
3. Burr and turn metal with a burring machine and by hand
4. Do elbow edging
5. Do ogee single and triple beading
6. Crimp a piece of metal to shrink edges
7. Drill a piece of metal by machine and by hand
8. Trim with a cold chisel
9. Sketch metal with hammer for flange or joint
10. Use a hand swage
11. Anneal copper or brass
12. Give hammer finish to copper, brass, or iron
13. Apply lacquer finish
14. Color copper or brass
15. Etch copper or brass
16. Raise copper or brass
17. Clean copper with acid
18. Fold a curved edge
19. Double seam corners
20. Braze with hard solder
21. Solder aluminum
22. Form tubes
23. Lay out and form hinges
24. Solder with a blowpipe
25. Develop patterns for elbows
26. Develop patterns for conical objects
27. Develop patterns for oblique conical objects
28. Develop pattern for spout
29. Develop pattern for lip
30. Develop pattern for a tee
31. Lay out pattern for mitered corner
32. Draw and develop patterns by parallel line method, radial line method, and triangulation
33. Make Pittsburgh seam, Boston seam, drive slides, and "S" slides
34. Construct from square to round

3 Learning Units _____

THINGS TO KNOW



TO DEVELOP A PLAN of instruction for the sheet metal area of the comprehensive general shop which will meet the non-manipulative values and outcomes of an Industrial Arts program, the teacher must allow time for instruction relative to the technical aspects, consumer knowledge, and guidance values inherent in any good Industrial Arts program.

The following informational units are listed to assist the teacher in developing his plan of instruction. The pupil should know:

About Materials

1. The various kinds of sheet metal
2. Gauges of sheet metal
3. Kinds of solder and their uses
4. Kinds of flux and dipping solutions and their uses
5. Kinds and sizes of rivets
6. Standard sizes of soft iron wire
7. Methods of manufacturing tin plate
8. How galvanized iron is made—its grades and qualities
9. Composition of brass, copper, and aluminum
10. Specifications of grades of tin plate and galvanized iron

About Tools and Equipment

11. Care of tools and equipment
12. Names and adjustments of all hand tools, stakes, and machines used
13. Kinds and sizes of drills
14. Use of a circumference rule
15. Sizes and shapes of soldering coppers
16. Relative value of electric soldering coppers
17. Type of equipment used in blowpipe soldering
18. Type of equipment used in light sheet metal welding
19. Allowance for single hem, double hem, groove seam, and wire edge
20. Allowance for raised bottom, Pittsburgh seam, elbow edge, “S” slide, and drive slide
21. Kinds and sizes of rivets
22. Kinds and sizes of sheet metal screws

About Sheet Metal Trades

23. Heating, air conditioning, and roofing
24. Building aircraft
25. Coppersmithing
26. Making metal signs
27. Shipbuilding
28. Occupational information such as information on wages and hours, unions, apprenticeship programs, and opportunities for promotion

4 *Organization of Instruction*_____

INSTRUCTIONAL MATERIAL AND DEVICES



SHOP PROJECTS are the objects around which instruction is built, and through which the pupil is introduced to the different learning units.

Project Selection

Projects for beginning pupils should have only a few of the basic learning units. These should be selected by the teacher and required of all pupils as standard jobs. Sheet metal can be put to many uses and, therefore, lends itself very readily to a course of study featuring a progression from simple to more complex problems. Difficult operations can be included in projects that use small amounts of materials and are therefore comparatively inexpensive. The criteria for project selection should be based on the theory of beginning with a small number of fundamental learning units with new learning units added in each succeeding project. Each new project should provide practice in the units already learned. Final approval of the selection should rest with the teacher. A display case of finished projects will motivate the pupil's interest and aid him in making a selection.

Regardless of who makes the selection, projects should conform to definite standards, chief of which are the following:

1. Projects should contain some of the learning units desired.
2. They should be simple enough to be in the range of the pupil's ability and difficult enough to challenge his resourcefulness.

3. They should be of such nature that they can be handled under school shop conditions.
4. They should embody good design and have some intrinsic value to the home or community.
5. They should be of such character that they can be completed within a reasonable or specified time.
6. They should have value in the pupil's estimation so as to nurture further interest.

Use of Records, Forms, Charts, and Instructional Material

The industrial arts instructor of a comprehensive shop program is confronted with hundreds of problems that have to do with the administration of the program, details of instruction, and the handling of supplies. The number of problems increases as the activities in the shop become more diversified.

Industrial arts instructors are therefore confronted with the necessity of using information sheets, job assignment sheets, operation sheets, project record cards, and progress charts, and of delegating many responsibilities to pupil personnel.

When shop work was first introduced into the public schools, instructors had a feeling that it provided a means of escape from the "drudgery of books." Because of this misconception, very little use was made of written materials. In recent years, however, through need for help in the handling of more than one activity at a time, and through the forward strides made in the writing and publishing of well-written materials, Industrial Arts teachers are learning to use printed material advantageously. Some of the advantages of using written material may be stated as follows:

1. It gives the instructor more time to select instructional material and to arrange it in the best learning order.
2. It makes more accurate instruction possible.
3. It places on the pupil the responsibility of seeking information.
4. It lends itself to accurate record-keeping and checking.
5. Larger classes can be handled more effectively.
6. It gives the instructor more time for individual help.

In using instruction sheets, instructors should be careful not to let them take the place of personal instruction and demonstration. It should be kept in mind that the main purpose of an instructional

aid is to help the shop instructor who may need to supervise several activities in progress at the same time, and not to replace the personal contact the instructor should have with pupils at all times.

Care should be taken that the instructor does not become so involved with keeping records that his clerical work detracts from his teaching. These instructional aids can be filed by the pupil when the information is arranged according to the plans which follow:

The Teacher Project Analysis Sheet (See sample on p. 14)

The teacher should carefully analyze each project, making a list of learning units and deciding on the most advantageous sequence of operations. The teacher's analysis should contain a page reference to books or instruction sheets. Points at which the work should be checked are indicated on this plan.

The Information Sheet (See sample on p. 15)

The Information Sheet presents selected information on a given material, manufacturing processes, and sources which are closely related to the activity. Information sheets on many subjects can be had in printed form from publishers of industrial subjects. However, it is sometimes necessary for instructors to prepare their own information sheets of subjects when they cannot be obtained in printed form.

The Project Assignment Sheet (See samples on pages 16 and 18)

When the above analyses have been made, a project assignment can be made for each project. Ordinarily this should include the following items:

1. A drawing with specifications for the project. (Mimeographed, printed, or blueprinted.)
2. A list of learning units with page reference for each.
3. A form on which the pupil plans his job. (See page 19.)

The Project Assignment Sheet is concerned primarily with assigning the pupil to a particular job. The sheet presents the job in its entirety, showing steps of procedure and listing references that describe the operations or processes. Where adequate reference material is not available, the term "demonstration" is inserted to show the steps the instructor is to demonstrate. Check marks can be made on project assignment sheets showing the pupil where he must review his progress with the teacher before going on with his work. The individual pupil can progress at his own rate and the teacher will know that each pupil

has had experiences in the essential manipulative activities. The project assignment sheet is helpful in starting the entire class with a minimum of confusion. As the class advances in knowledge and skills, the project assignment sheet is modified so that the pupil can prepare his own project assignment sheet on a project of his own choice after securing the teacher's approval. A skeleton form (mimeographed or printed) should be provided by the instructor to maintain uniformity. (See page 19.)

SAMPLE TEACHER PROJECT ANALYSIS SHEET

NOTE: This analysis of a few sheet metal projects is presented as an example of form. Each teacher should select projects that answer the needs of his program—not necessarily the projects listed below. An analysis should be made of each selected project. The numbers under the headings “Things to Do” (pages 5 to 7) and “Things to Know” (pages 9 to 10) refer to the lists of units in this bulletin. Reference books or instruction sheets used in the shop should be listed as to title and page, preferably coded, in the spaces provided.

Suggested Projects for Grades 7, 8, and 9

<i>Grade</i>	<i>Project</i>	<i>Project Reference Books</i>	<i>Things to Do</i>	<i>Things to Know</i>	<i>Informa- tion Reference Books</i>
7	Cookie cutter	Code references here	1, 2, 3, 4, 6, 7, 8, 12, 13, 14, 15, 19, 22, 32	1, 3, 7, 15, 19	Code references here
	Sugar scoop		1, 2, 3, 4, 5, 6, 8, 10, 11, 13, 15	2, 4, 7, 16, 19	
8	Pancake turner		1, 2, 3, 4, 5, 6, 27, 29, 42	2, 5, 9, 13, 21	
	Fruit jar filler		1, 2, 4, 5, 6, 7, 8, 13, 14, 17, 18, 21, 23, 29, 37	10, 12, 19	
9	Dustpan		1, 2, 3, 4, 5, 6, 7, 8, 9, 13, 14, 15, 16, 20, 24, 27, 32	1, 2, 3, 4, 5, 6, 7, 10	

SAMPLE INFORMATION SHEET (See page 13)

ACTIVITY: Sheet Metal

UNIT No. 1

SHEET No. 2

SUBJECT: Copper

Copper has always been the world's most versatile metal. Copper and its alloys have a part in almost every phase of our industrial and everyday life. Many people believe that copper was the first metal used by man, since weapons, utensils, and ornaments manufactured from copper can be traced back as far as 5000 B. C.

The electric current which powers our great industrial machines, lights our homes, and carries our telephone conversation is conducted by copper wires. Our modern refrigeration and many of our heating systems make extensive use of copper. Brass tubing and copper tubing carry rust-free water into our homes.

If the house in which we live is well constructed it may have a copper roof; at least it will have copper gutters, flashing, and downspouts. Many of our better kitchen utensils are made of copper or one of its alloys. Today copper is alloyed with tin to make bronze; alloyed with zinc to make brass; and alloyed with various other metals to produce many fabricated materials.

The largest copper deposit in the world is in Chile. Canada has become an important producer since 1930.

QUESTIONS

1. Name three important uses of copper.
2. Where is the largest deposit of copper found?
3. Name two alloys containing copper.
4. Name five uses of copper in the home.
5. When was copper first used by man?

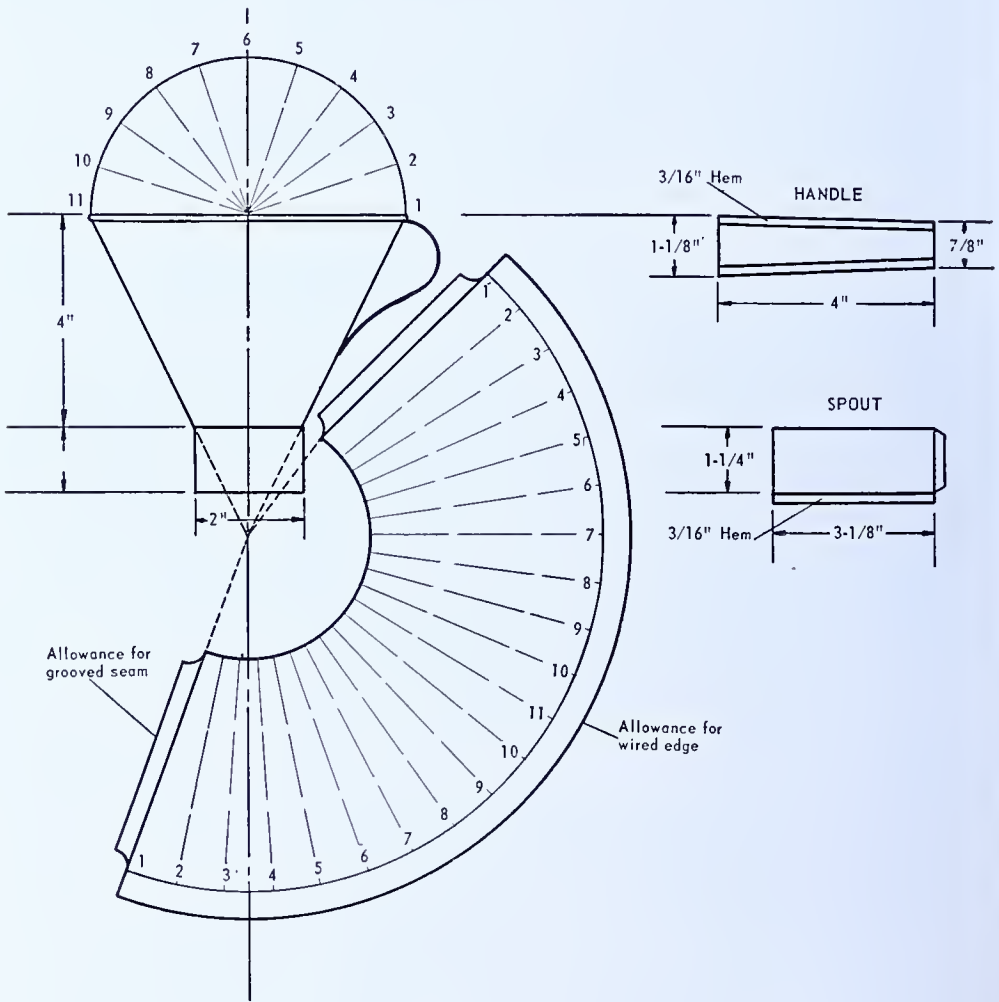
REFERENCES

- Glover and Cornell, *The Development of American Industries*.
Prentice-Hall, Inc., New York City, N. Y.
- Fryklund and Sechrist, *Materials of Construction*. Bruce Publishing
Co., Milwaukee, Wis.

SAMPLE PROJECT ASSIGNMENT SHEET

TO MAKE A FRUIT JAR FILLER

Specifications: Use 1X tin. Top edge of body wired with No. 12 wire. Groove body seam with No. 5 hand groover. Solder spout and handle to body.



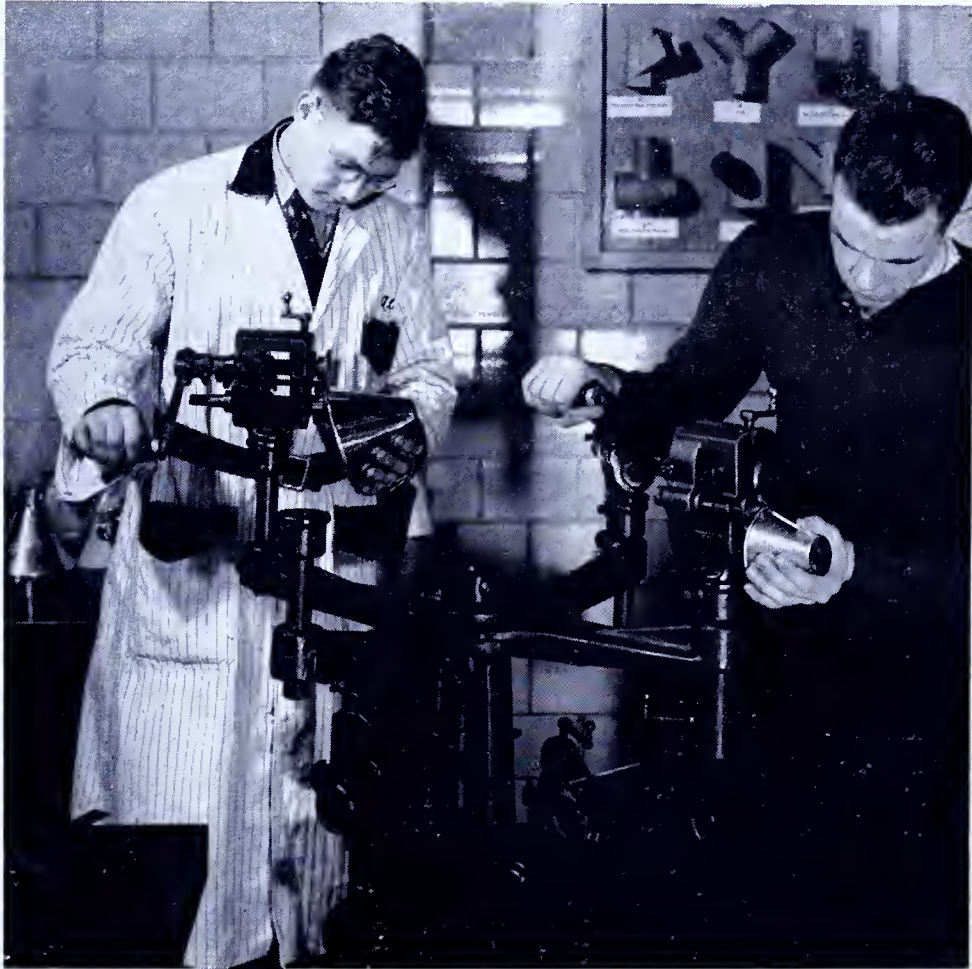
THINGS TO BE LEARNED ON THE PROJECT

In making this fruit jar filler you will not only use some of the skills you have already learned but will also acquire some new skills.

The number of the instruction sheet or the number and page of the reference book are given in the reference column to the right.

1. Lay out simple rectangular, cylindrical, and conical forms on sheet metal
2. Plan the procedure for doing the job
3. Use dividers or compass, laying out curves and dividing spaces
4. Transfer patterns to sheet metal
5. Cut out patterns using straight snips
6. Form by hand
7. Turn edges for a hem
8. Wire a cone-shaped object
9. Make a grooved seam with a hand groover
10. Solder tin plate

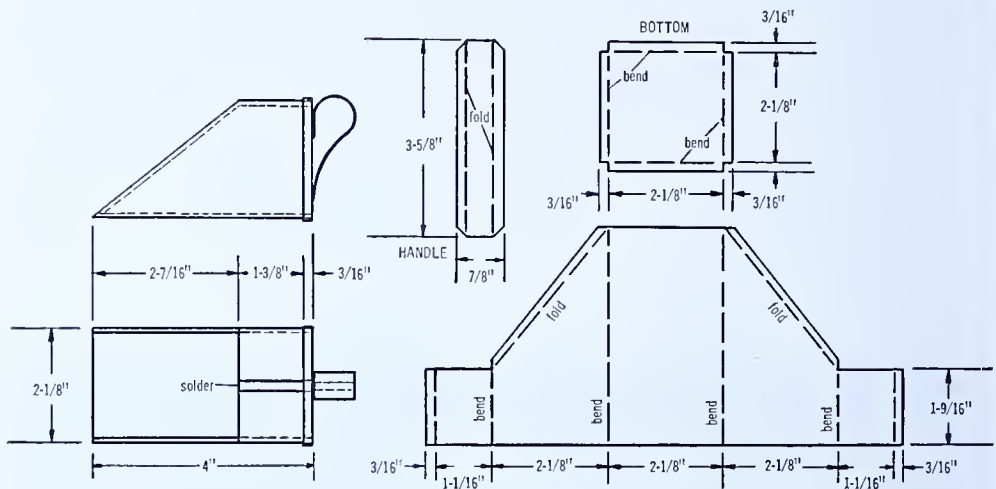
Code References Here



SAMPLE PROJECT ASSIGNMENT SHEET

TO MAKE A SUGAR SCOOP

Specifications: Use IX tin. Fold, bend, and solder according to directions given on the drawing. Solder handle to bottom after it is fastened to body of scoop.



THINGS TO BE LEARNED ON THE PROJECT

In making this sugar scoop you will not only use some of the skills you have already learned but will also acquire some new skills.

The number of the instruction sheet or the number and page of the reference book are given in the reference column to the right.

References

1. Lay out simple rectangular form on sheet metal
2. Plan the procedure for doing the job
3. Transfer patterns to sheet metal
4. Cut out patterns using straight snips
5. Form by hand according to instructions on drawing
6. Fold edges for hem
7. Form bottom on bar folder according to chart
8. Solder seam on body
9. Assemble and solder bottom to body
10. Form handle and solder to body.

Code References Here

SAMPLE PUPIL PROJECT PLAN (See page 13)

..... HIGH SCHOOL

..... SCHOOL DISTRICT

Name Grade..... Section.....

Project..... Teacher Approval..... Date.....

SKETCH: Make a working sketch of the project to be made.

PROCEDURE: List the principal steps in doing the project, showing what you will do first, second, third, etc.

- 1.
- 2.
- 3.
- 4.
- 5.
- 6.
- 7.
- 8.
- 9.

The Operation Sheet

The operation sheet presents the steps necessary in performing one operation or process containing a number of skilled manipulations. Typical titles are: "Sweat a Joint"; "Wire An Edge." A great variety of such material is available in book or manual form from industrial education publishing companies.

The Cumulative Project Record Card (See sample below)

The Cumulative Project Record Card is a convenient and organized device for keeping a record of each pupil's progress and his experiences in making projects. It is helpful to the teacher in planning the instructional program for each pupil from semester to semester or from year to year. It is also valuable to those responsible for guidance, placement, and follow-up.

The Progress Chart (See sample, p. 21)

The Progress Chart checks the accomplishment of pupils where instruction is individualized. Simple progress charts contain a list

Name

Grade 789101112PG

PUPIL CUMULATIVE PROJECT RECORD

Industrial Arts Department

School

City

Shop	Project	Activity	Date Started	Date Finished	Total Periods	Teacher	Cost	Paid	Grade

Sample of a Cumulative Project Record Form to be Kept Throughout a Pupil's School Experience in Graphic Arts.

[illegible]

of names along one side of a sheet, and a list of jobs, processes, or assignments along the other side. The progress chart aids the teacher in keeping an accurate record of pupil achievement and, if used properly, can be a factor in motivating interest. Charts can be kept in the instructor's notebook, on a large piece of cardboard, hung on the wall, or kept in the pupil's notebook. Regardless of the method used in keeping this chart, the instructor does the marking in order to keep the records correct.

Of the many factors that contribute to good teaching, organization and planning are the most important. Without a plan, important points will be omitted, continuity of presentation will suffer, and the attainment of good objectives will be doubtful.

Teacher Preparation

- 21

Starting the Class

1. Introduce yourself to class (write name on blackboard)
2. Have pupils fill in information necessary for registration
3. Assign each pupil to a report station and locker
4. Explain organization of class, purpose of course, and shop procedure
5. Pass out job assignment sheets and explain briefly how they are used
6. Call group to demonstration bench and demonstrate first steps
7. Issue material and start class to work

Shop Management Organization

As the activities presented in Industrial Arts shops are increased in number and scope, it is expedient for the teacher to assign some of the clerical, preparatory, maintenance, and routine duties to pupils. The pupil organization will vary according to type of activity, size of class, age of pupils, and the physical layout of the shop.

Experienced Industrial Arts teachers recognize that valuable training results from a good pupil personnel organization. Pupil participation in the administration of classroom procedures will:

1. Provide training in leadership
2. Develop responsibility and a feeling of belonging to the activity
3. Aid in motivating the pupils' interest in industrial operations and applications
4. Aid the otherwise busy teacher in handling routine duties

In order to make any pupil personnel organization successful, its importance, need, and practicability must be explained carefully to the pupils. The success of the program depends entirely on the pupils' acceptance. The teacher should plan his presentation carefully in order to justify the value and need of such a program in the minds of the pupils.

Because a teacher-imposed plan is readily recognized by the pupils and has a tendency to destroy pupil interest, better cooperation can be developed through a personnel plan developed by the pupils with teacher guidance. A plan developed by a class or several classes motivates the pupils' interest in industrial personnel organizations, and a study of local plan systems will be valuable in directing a well-organized plan for the school. The added cooperation attained and the guidance value received by the pupils more than compensate for

the extra time spent in the democratic development of this plan. A plan for setting up a pupil personnel organization is given in Bulletin 331, *Industrial Arts in Pennsylvania*, 1951.

The following listing of pupil officers and duties is merely suggested and should be modified to fit local conditions and shop organization:

1. SHOP SUPERINTENDENT

The position of superintendent is the most important one in the shop. Encourage pupils to look forward to attaining this position.

Duties

- a. Report to the shop as soon as possible after the bell rings.
- b. Obtain keys from the teacher and unlock the project storage cabinets. Unlock tool cabinets. Be sure that the foreman is there to check tools.
- c. Close shop door when tardy bell rings.
- d. Assist teacher in any way possible.
- e. See that all foremen are taking care of assignments.
- f. When clean-up bell rings, see that pupils clean up promptly. Lock cabinets after the foremen have finished checking, and return keys to teacher.
- g. The position of superintendent is very important. The time it takes to discharge the responsibilities in an efficient manner will vary, but there should always be adequate time to spend on individual assignments.

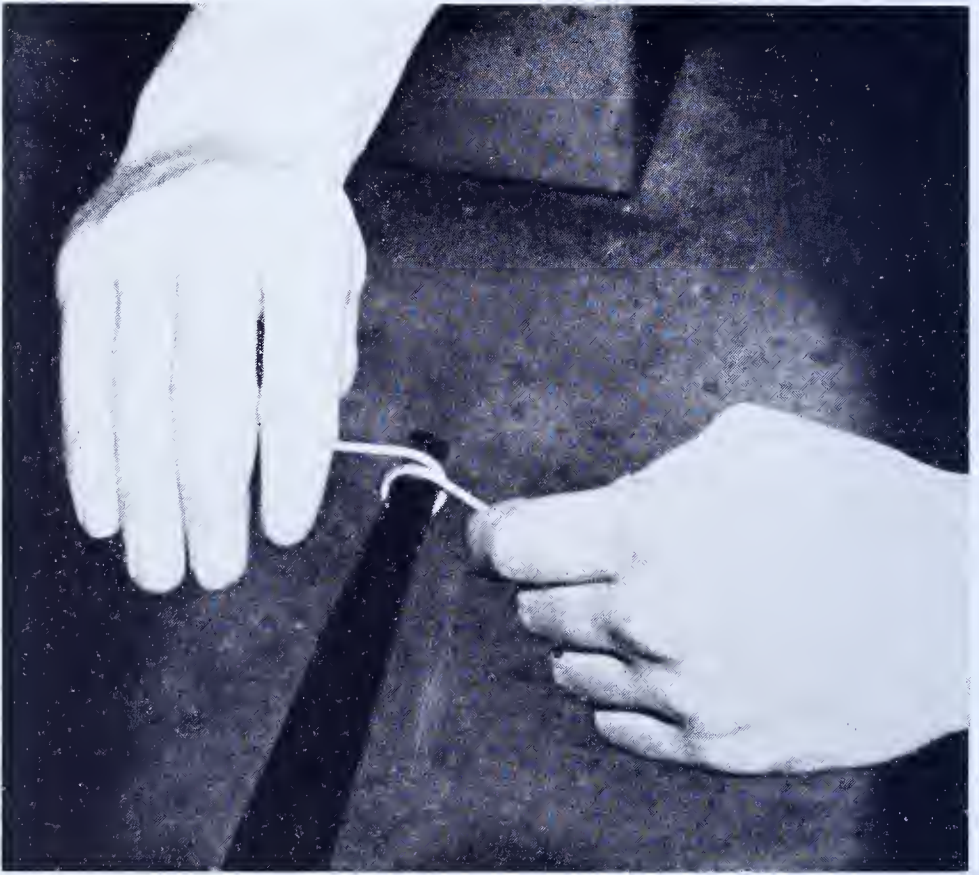
2. TOOL ROOM FOREMAN

Duties

- a. Inspect all tools and report any missing or broken tools to shop superintendent.
- b. Check out tools to pupils.
- c. Repair and sharpen tools.
- d. Check tools and inspect for cleanliness.
- e. Report to shop superintendent when all tools are checked in.
- f. During the working period, the tool room foreman should have considerable time to work on his own project. However, he should keep in mind the importance of the care of the tools.

Note to Instructor:

If open tool panels are used in the activity areas the tool room foreman would have the same duties as are listed above except that item b should be eliminated and item d changed to "Check tool panels."



3. SAFETY ENGINEER

Duties

- a. Responsibility for the proper usage of tools, equipment, and supplies so as to insure pupil safety.
- b. Check to see that pupils follow the safety rules.
- c. Check on loose clothing—ties, etc.
- d. See that goggles or face shields are used whenever necessary.
- e. Spend as much time as possible on the individual assignment, remembering, however, that safety in the shop is the main responsibility.
- f. Administer first aid in minor cases and report all injuries to the teacher.

4. MAINTENANCE FOREMAN

Duties

- a. Check to see that all machines and benches are clean at the beginning and end of the period.

- b. Check lockers and cabinets to see that everything is in order at the end of the period.
- c. Accept responsibility for keeping the layout table, machine table, and the soldering bench clean.
- d. Put large scrap pieces in scrap box.
- e. Spend some time on own assignment.
- f. Report to superintendent when everything is in good order.

Rotating Assignments in Shop Management Organization

Any plan devised for rotating pupils through the officer personnel organization must be simple and easily administered. The teacher should guard against allowing the more capable pupils to hold offices for a longer period of time than others in order to produce a smoother running organization. All pupils should be given equal opportunity to serve as an officer. Several devices have been used successfully in rotating pupil assignments. One mechanical device used by several schools is illustrated on page 84 in Bulletin 331, *Industrial Arts in Pennsylvania*, published by the State Department of Public Instruction in 1951.

Some teachers prefer to use a mimeographed form listing jobs with space for names of the pupils assigned to these jobs. It is good practice to identify the pupil's name with the responsibility assigned to him. Having the outgoing officers spend one day with new officers in order to teach them their new duties is helpful to teachers. The time pupils serve will vary according to the size of the class. However, each pupil should serve at least once. Another method used in rotating assignments can be found on page 119 of the March, 1948, issue of *Industrial Arts and Vocational Education*.

PARTIAL CHECK LIST ON CARE OF THE SHOP

This check list may serve as a guide to the teacher in keeping the sheet metal area functioning in good order.

	<i>Yes</i>	<i>No</i>
1. A place for everything and everything in its place.....	_____	_____
2. A well-kept lumber room or rack	_____	_____
3. Tools clean and in order	_____	_____
4. Benches and machines well arranged	_____	_____
5. Benches and machines kept clean	_____	_____
6. Blackboard clean and presentable	_____	_____
7. Bulletin board material well arranged and changed frequently	_____	_____
8. Finishing room kept clean and orderly	_____	_____
9. Floor cleaned daily	_____	_____
10. Teacher's desk in order	_____	_____
11. Books, pamphlets, blueprints clean and well arranged....	_____	_____
12. A box for scraps	_____	_____
13. A metal container for oily rags	_____	_____
14. Lockers in good order	_____	_____
15. Sinks kept clean	_____	_____
16. Out-of-the-way places swept and dusted frequently.....	_____	_____
17. Project storage in good order	_____	_____
18.	_____	_____
19.	_____	_____
20.	_____	_____

5 *Instructional Aids*_____

BOOKS, FREE MATERIALS, FILMS



IN A BULLETIN of this size it is impossible to list all of the instructional materials in the form of books, pamphlets, study guides, and charts. Many instructors may be using excellent instructional aids not included here. This listing is not exhaustive.

Certain instructional materials are listed, however, with author, publisher, address of publisher, and an annotation of the contents, so that the Industrial Arts teacher will know what phase of instruction is included in each reference.

BOOKS

- Bedell, E. L., and Gardner, E. G., *Household Mechanics Industrial Arts for the General Shop*. Scranton, Pa., International Textbook Co., 1945, 241 pp. \$2.60

The logical relation between the *know what* and the *know how* in instruction is developed by means of 148 jobs which introduce pupils to many shop experiences and manipulative processes. This book is well adapted to a comprehensive general shop program.

- Bollinger, J. W., *A Course in Sheet Metal Work for Junior High Schools*. Milwaukee, Wis., Bruce Publishing Co., 1925, 96 pp. \$.88

An elementary treatment of first principles, consisting of simple projects, with illustrations, diagrams, and complete instructions requiring a minimum of equipment.

- Broemel, L., *Sheet Metal Workers' Manual*. Chicago, Ill., Frederick J. Drake & Co., 1942, 550 pp. \$3.00

A basic text helpful to the sheet metal teacher as a technical reference book. Hand tool processes are well illustrated.

- Butler, J. C., *Sheet Metal Theory and Practice*. New York, N. Y., John Wiley & Sons, 1944, 173 pp. \$3.00

Pertinent information on tools and equipment, riveted assembly, soldering and fluxes, seams and locks, blueprint reading, measuring, templating, use of paper patterns, material allowances, ventilation and heating, furniture, lockers, shelves, dressers, materials, and shop practices.

- Daugherty, J. S., *Sheet Metal Pattern Drafting and Shop Problems* (School Edition). Peoria, Ill., Charles A. Bennett Co., 1922, 173 pp. \$2.48

Contains many typical problems and easily constructed projects. Each is illustrated with a photograph of the finished project and a detailed drawing with step-by-step instructions. The book presents a basic knowledge of the trade.

- Delmar Publishers, *Hand Processes Sheet Metal Series*. Albany, N. Y., 1946, 196 pp. \$1.60

Presents the hand processes performed in sheet metal work with bench and layout tools. A helpful reference text for use with instruction sheets.

- Delmar Publishers, *Machine Processes Sheet Metal Series*. Albany, N. Y., 1946, 86 pp. \$1.50

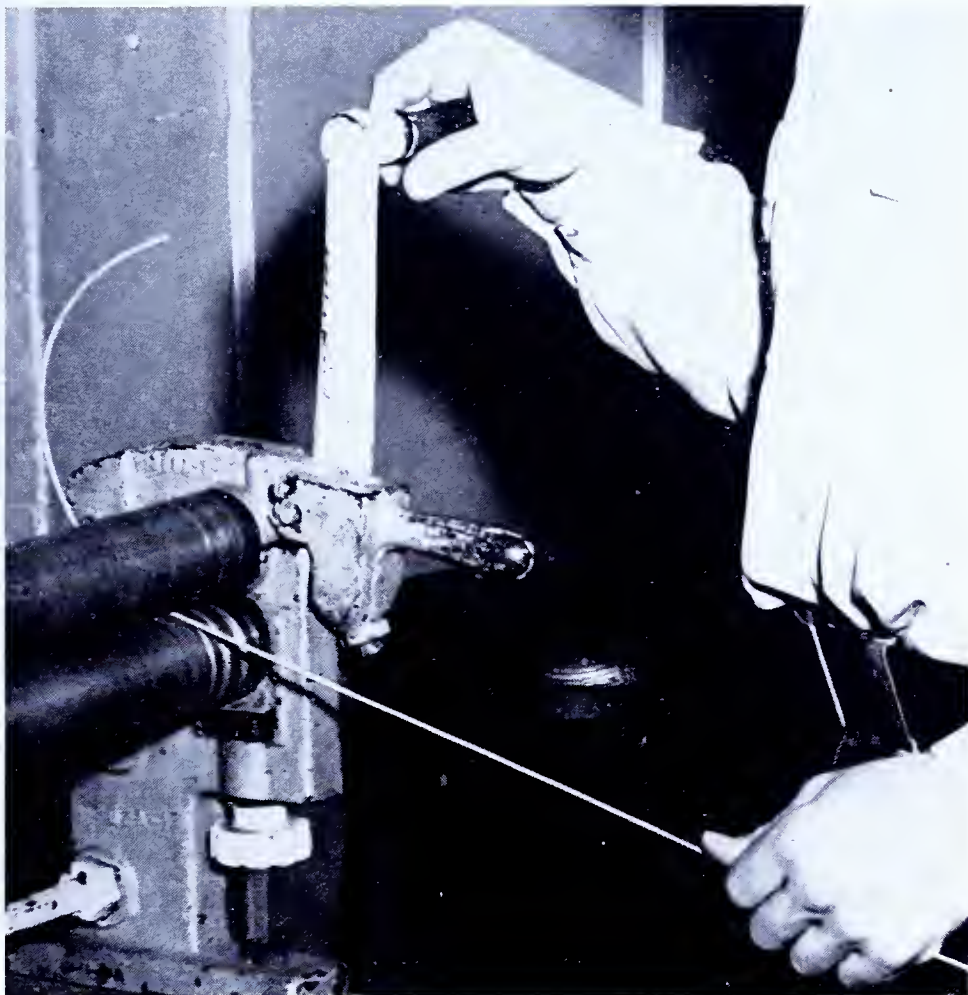
A well-illustrated book showing step-by-step procedures in forming sheet metal with hand machines. A good reference book that can be used advantageously with instruction sheets.

- Dragoo, A. W., and Reed, H. O., *General Shop Metalwork*. Bloomington, Ill., McKnight & McKnight Publishing Co., 1947, 102 pp. \$1.25

Short teaching units cover work in beginning bench metal, sheet metal, art metal and ornamental metal. Includes designs and directions for 28 projects of a practical, usable nature, which give the pupils practice in operations while making a project of value. A good reference book for use with instruction sheets.

- Fryklund, J. C., and Sechrist, C. H., *Materials of Construction*. Milwaukee, Wis., Bruce Publishing Co., 1943, 276 pp. \$3.50

- Glover, J. G., and Cornell, W. B., *Development of American Industries*. New York. Prentice-Hall, Inc., 1941, 1005 pp. \$5.50



Jenkins, Rolland, *Sheet Metal Pattern Layout*. New York, N. Y., Prentice-Hall, Inc., 1949, 75 pp. \$2.25

Shows how to make the patterns for various forms of sheet metal parts through easy steps.

Kaberlein, Joseph J., *Short Cuts for Round Layouts*. Milwaukee, Wis., Bruce Publishing Co., 1947, 280 pp. \$3.75

A working guide with practical and modern methods for laying out and forming patterns used for round elbows, angles, T's, offsets, tapers, cones, branches, and cyclones, with mathematical formulas.

Kaberlein, Joseph J., *Triangulation Short Cut Layouts*. Milwaukee, Wis., Bruce Publishing Co., 1948, 204 pp. \$5.00

Practical and exhaust methods for laying out and forming patterns for blower and exhaust systems, heating, and air conditioning. Short form for industrial use is presented in 146 illustrated projects.

Luckowitz, J. J., *New Tin Can Project*. Milwaukee, Wis., Bruce Publishing Co., 80 pp. \$1.50

Plans for making 55 attractive projects from discarded tin cans, with directions for making jigs to help in manufacture.

Schultz, L. C., and Schultz, L. J., *School and Home Shop Work*. New York, N. Y., Allyn & Bacon, 1949, 246 pp. \$2.75

Units in mechanical drawing, woodworking, general mechanics, electricity, metalworking and automobile mechanics. The book can be used in general shop work through the use of instruction sheets.

Smith, Robert E., *Units in Sheet Metal Work*. Bloomington, Ill., McKnight & McKnight Publishing Co., 1939, 47 pp. \$1.00

A beginning course organized in short teaching units, with correct procedures illustrated. Related information is presented on processes and sheet metal occupations. Projects are suggested.

Tustison, F. E., and Kranzusch, R. F., *Metalwork Essentials*. Milwaukee, Wis., Bruce Publishing Co., 1936, 176 pp. \$1.75

Contains well-prepared information units on the various processes involved in forming sheet metal.

Welch, R. L., *Elements of Sheet Metal Work*. Milwaukee, Wis., Bruce Publishing Co., 1949, 124 pp. \$1.96

A complete course in elementary sheet metal work without engineering details and involved technical descriptions. It begins with basic problems and proceeds through tools and processes to the more complicated trade methods.

Yerkow, Charles, *Fundamentals of Soft Soldering*. Peoria, Ill., Charles A. Bennett Co., 1949, 96 pp. \$2.25

How to solve soft-soldering problems. Illustrates and explains how to apply flux and solder by iron and direct heat for making all fundamental joints.

FREE MATERIALS

American Rolling Mill Company, Middleton, Ohio. "Short Method of Pattern Development," by Ralph W. Poe.

American Rolling Mill Company, Middleton, Ohio. "Fundamentals of Pattern Drafting and Blueprint Reading for Sheet Metal Shops."

American Steel and Wire Company, Cleveland, Ohio. "Making Steel and Wire."

Kester Solder Company, 4201 Wrightwood Avenue, Chicago, Illinois. "Kester Solder Reference Chart."

Kester Solder Company, 4201 Wrightwood Avenue, Chicago, Illinois. "Facts on Soldering."

The Ruby Chemical Company, Columbus, Ohio. Leaflets on materials for soldering stainless steels and methods of procedure.

The Turner Brass Works, Sycamore, Illinois. Illustrated leaflets on the care and use of the blowtorch.

FILM SOURCES AND TITLES

Motion Pictures

- Aluminum Fabricating Processes.* 20 min., 16 and 35 mm., sound, free. Aluminum Company of America, Motion Picture Department, 801 Gulf Bldg., Pittsburgh 19, Pa.
- Aluminum—Mine to Metal.* 15 min., 16 and 35 mm., silent, 2 reels, free. Aluminum Company of America, Motion Picture Department, 801 Gulf Bldg., Pittsburgh 19, Pa.
- Care of Minor Wounds.* Audio-Visual Aids Library, The Pennsylvania State College, State College, Pa.
- Care and Use of Hand Tools—Hacksaws.* National Safety Council, 425 North Michigan Ave., Chicago 11, Ill.
- Care and Use of Hand Tools—Hammers.* National Safety Council, 425 North Michigan Ave., Chicago 11, Ill.
- Fabrication of Copper.* Department of the Interior, Bureau of Mines, 4800 Forbes St., Pittsburgh 13, Pa.
- General Sheet Metal Practice.* 20 min., 16 and 35 mm., sound, free. Aluminum Company of America, Motion Picture Department, 801 Gulf Bldg., Pittsburgh 19, Pa.
- Grinding Wheel Safety.* Norton Abrasives, Worchester, Mass.
- Heating and Air Conditioning.* 11 min., 16 mm., sound, \$1.25 rental. University of Wisconsin, Bureau of Visual Education, University Extension Division, Madison 6, Wis.
- Story of Copper, The.* 16 mm., sound, 3 reels, \$.50 rental. University of Kansas, Bureau of Visual Education, University Extension Division, Lawrence, Kans.
- Safety Sleuth, The.* National Safety Council, 425 North Michigan Ave., Chicago 11, Ill.
- This Is Aluminum.* 35 min., 16 and 35 mm., sound, free. Aluminum Company of America, Motion Picture Department, 801 Gulf Bldg., Pittsburgh 19, Pa.
- Tin from Bolivia.* 20 min., 16 mm., sound, free. Department of the Interior, Bureau of Mines, 4800 Forbes Street, Pittsburgh 13, Pa.
- Unfinished Rainbow, The.* 37 min., 16 and 35 mm., sound, free. Aluminum Company of America, Motion Picture Dept., 801 Gulf Bldg., Pittsburgh 19, Pa.
- Welding the Safe Way.* National Safety Council, 425 North Michigan Ave., Chicago 11, Ill.

Slidefilms

- Basic Shop Safety.* Jam Handy Organization, 2821 East Grand Blvd., Detroit 11, Michigan
- Safe Handling of Materials.* National Safety Council, 425 North Michigan Avenue, Chicago 11, Illinois
- Safe Practices—Metalworking.* Jam Handy Organization, 2821 East Grand Blvd., Detroit 11, Michigan

SAFETY BOOKLETS

Safe Work Practice in Sheet Metal Work. American Technical Society, Drexel Avenue and 58th Street, Chicago, Illinois.

Safety in the School Shop. Henry Ford Trade School, Dearborn, Michigan

Safety Code for Industrial Arts Shops. Central High School, Industrial Arts Department, Trenton, New Jersey, 1948

Sheet Metal Safety Training. Bulletin 47 B, State Board of Vocational and Adult Education, Madison, Wisconsin, 1944

Welding Shop Safety Training. Wisconsin State Board of Vocational and Adult Education, Madison, Wisconsin, 1944

6 *Equipment and Supplies*————

MACHINERY AND SUPPLY LISTS



THIS SECTION SUGGESTS to the teacher of Industrial Arts how to select equipment and consumable supplies, and how to order them. In addition, lists of equipment and supplies needed for the Sheet Metal Area are presented.

The machinery, tools, supplies, and other equipment recommended in this bulletin are based on the minimum requirements for five pupils in a comprehensive general shop sheet metal area. A larger number of pupils can be accommodated by increasing the amounts proportionately. The costs of tools, equipment, and supplies

given in this bulletin are as of January 1, 1951, and are subject to market fluctuations. In any case where a manufacturer's name is specified, it should not be taken for granted that it is preferred to products of other manufacturers.

How to Select Equipment

Several factors are to be considered in determining the quantity and type of equipment to be selected for the Sheet Metal area of the comprehensive general shop. Briefly, they are as follows:

1. The objectives to be attained through its use
2. The activities planned
3. The size of the class
4. Content and scope of the course
5. Whether used in junior or senior high school, or both
6. Funds available

How to Specify and Order Equipment and Supplies

After approval has been granted by the board of school directors to purchase equipment, tools, and supplies for the Industrial Arts activity, specifications must be written. It is important that a detailed description be given for each tool or piece of equipment so that the quality desired may be obtained, and bidders on the materials may know that substitutions cannot be made.

How to Keep a Shop Inventory

The type of inventory used depends on the local school organization. In large school systems, methods of keeping inventories are determined by the administrative office. However, in smaller systems, the job of keeping an inventory is the duty of the individual shop teacher. The advantages of keeping an accurate inventory are many. The more important ones are:

1. Tells at all times how much stock is on hand
2. Tells the amount used during the past year
3. Determines the amount needed for the next year
4. Justifies quantities on requisitions to the superintendent and board of school directors

SAMPLE INVENTORY

<i>On Hand</i>			<i>Cost</i>		
<i>Start of Year</i>	<i>End of Year</i>	<i>To Be Ordered</i>	<i>Description</i>	<i>Each</i>	<i>Total</i>
1 sheet	0	1 sheet	Copper, .022, 1602, 24" x 96", cold rolled	\$13.48	\$13.48
12	6	6	Handles, soldering copper ...	.15	.90
1 gr.	½ gr.	½ gr.	Screws, sheet metal, No. 4, ⅜", self-tapping, plain steel finish	1.50 gr	.75
6	0	6 bars	Solder, 1½ lb. bars, half-and- half	1.14	6.84

MACHINERY, EQUIPMENT, AND TOOL LIST

Machinery

<i>Quantity</i>	<i>Item</i>	<i>Approx. Cost</i>
1	Bar Folder, 30", with counterbalance	\$165.00
1	Bench, sheet metal, 2¼" thick-edge grain, edges protected by 2¼" x 2¼" angle irons, three shelves. Top to be provided with a bench plate on either side for mounting the various stakes used in forming sheet metal	391.50
2	Furnace, gas double burner with firebrick	19.82
2	Machinists' vise, stationary base, width of jaw 3½", jaw open 5½"	40.50
1	Rotary Machine, complete with five pairs of rolls: crimping, turning, burring, wiring, and ogee beading, including bench standard and gauge. Depth, throat to gauge, 6"	88.00
1	Slip roll former, 36"	105.60
1	Turning machine, 1½" rolls, wires from 7 to 11	50.60

Equipment

1	Blowhorn stake, 27"	22.00
1	Common square stake, 2½" x 4½"	8.25
1	Conductor stake, 28"	17.60
1	Double seaming stake, 29"	28.60
1	Hatchet stake, 13"	13.20
1	Hollow mandrel stake, 40"	26.40

Hand Tools

<i>Quantity</i>	<i>Item</i>	<i>Approx. Cost</i>
4	Awl, Scratch	\$.60
Coppers:		
2 pr.	soldering, 2 lbs. per pair	1.80
1 pr.	soldering, 3 lbs. per pair	2.60
2	Dividers, 8", solid nut	2.82
Groovers:		
1	hand, 7/32"	1.59
1	hand, 5/16"	1.67
1	hand, 3/8"	1.84
Hammers:		
2	ball peen, 12 oz.	2.70
2	ball peen, 16 oz.	2.90
2	raising, 28 oz.	7.96
2	tinner's riveting, 12 oz.	1.75
4	tinner's setting, 12 oz.	1.75

<i>Quantity</i>	<i>Item</i>	<i>Approx. Cost</i>
2	Mallets, tinners, 3" x 6"	
1	Nippers, wire-cutting, 12"	\$2.32
		3.91
	Punches:	
2	center, $\frac{3}{8}$ " x 5"	
2	center, $\frac{1}{2}$ " x $5\frac{1}{2}$" .....	.86
2	hollow, $\frac{1}{4}$ "	1.00
2	hollow, $\frac{3}{8}$ "	2.34
2	hollow, $\frac{1}{2}$ "	3.20
1	hollow, $\frac{3}{4}$ "	3.68
1	hollow, 1"	3.34
2	prick, $\frac{3}{8}$ " x 5"	5.43
2	solid, #3	1.00
2	solid, #5 .....	.76
2	solid, #6 .....	.76
2	solid, #7 .....	.76
	Pliers:	
1	7", diagonal	2.22
2	6", flat nose	3.08
2	6", round nose	4.16
	Rule:	
1	circumference, 36"	5.50
2	steel, $1\frac{1}{4}$ " x 2' in 16ths	3.76
	Sets:	
1	rivet, #2	1.05
1	rivet, #4 .....	.88
1	rivet, #6 .....	.67
	Snips:	
2	curved, 3" jaw	5.28
2	combination, 3" jaw	8.36
1	hawks-bill, 3" jaw	5.61
2	straight, 3" jaw	7.48
2	Squares, steel, 12" x 18"	3.50
	Total	<hr/> \$1,088.72

CONSUMABLE SUPPLIES LIST

The supplies listed below are based on the needs for the sheet metal area of a comprehensive general shop with a five- to six-pupil load, six periods per day, for 36 weeks. This list is suggestive and can be varied by the local Industrial Arts teacher to meet the requirements of his specific course of study. It should be used as a guide and not as a final form for requisitioning. Supplies that are commonly used by the entire school system are not listed.

Metal Sheets

<i>Quantity</i>	<i>Item</i>	<i>Approx. Cost</i>
Copper:		
1 sheet	.022", 16 oz., 24" x 96" cold rolled	\$13.48
1 sheet	.022", 16 oz., 24" x 96" soft rolled	12.43
4 sheets	Galvanized iron, 26 gauge, 24" x 96"	9.44
50 sheets	Tin plate, 1c, 20" x 28"	22.00

General Supplies

1 gal.	Acid, muriatic	2.50
2 doz.	Blades, hacksaw, 10", 18 teeth	3.12
100	Bolts, stove, 1/8" x 1" round head with nuts .....	.54
1 gal.	Fluid, soldering	2.10
12	Handles, soldering copper	1.72
6 doz.	Pail ears, tinned No. 20 .....	.90

RI,ETS:

8 oz.	copper, 1/8" .....	.81
8 oz.	copper, 3/16" .....	.81
1 lb.	tinner's, 1 lb.	1.32
1 lb.	tinner's, 2 1/2 lbs.	1.20
1 lb.	tinner's, 1 1/2 lbs.	1.32

SAL AMMONIAC:

5 lbs.	powdered .....	.75
3	bricks	1.31

SCREWS:

1 gr.	sheet metal, No. 4-3/8" round self-tapping, plain steel finish. ....	.50
1 gr.	sheet metal, No. 6-1 1/2" same as above	1.10
1 gr.	sheet metal, No. 6-3/8" same as above .....	.50
1 gr.	sheet metal, No. 8-1/2" same as above .....	.70

<i>Quantity</i>	<i>Item</i>	<i>Approx. Cost</i>
SOLDER:		
1 lb.	acid core	\$1.12
6	bar, 1½ lb. bars, half-and-half	6.84
1 lb.	resin core	1.12
1 doz.	Swabs, acid .....	.35
WIRE:		
5 lbs.	tinned annealed, #14	2.23
5 lbs.	tinned annealed, #12	2.15
5 lbs.	tinned annealed, #8	2.07
Total		<hr/> \$92.00

Storage and Control of Tools, Supplies, and Projects

The storage and arrangement of tools depend largely on the physical layout of the shop, type of activities, size of class, money available, and the ease with which the tools can be checked at the end of the shop period. The following methods of storage are most frequently used:

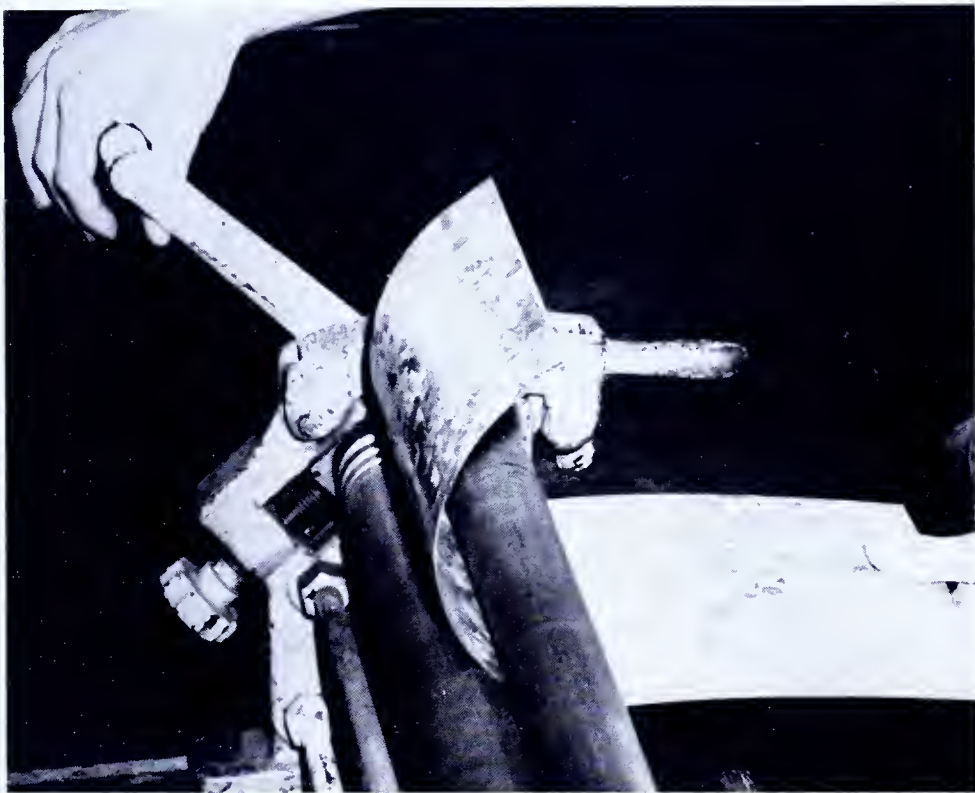
1. Tool room
2. Open tool panels (placed according to activities)
3. Tool cupboards
4. Bench racks
5. Bench drawers
6. Individual tool kits or boxes (used mostly for auto mechanics or machine shop)

The use of the open tool panel is recommended because of the simplicity of administration, economy of time in obtaining and returning tools, and the appearance of neatness it adds to the shop. Panels for tools normally used in a particular work area are fastened to a wall. Each panel is painted with a light background, and then the silhouette of each tool is painted on this background in a darker color.

Storage space for consumable supplies is a very important factor in the planning of building facilities for Industrial Arts programs. The comprehensive general shop frequently includes a unit in wood-working, which requires a dry and well-lighted room for the storage of supplies and projects. Metal racks should be constructed in this room for the different gauges of sheet metal, and there should also be a sufficient number of bins for the storage of unfinished projects. Provision should also be made for separate bins or shelves for each class section. The room should be large enough to store commercial stock sizes, and be arranged so that incoming supplies can be unloaded directly from the delivery truck into the storage room.

7 Suggested Shop Layout—

THE PHYSICAL NEED

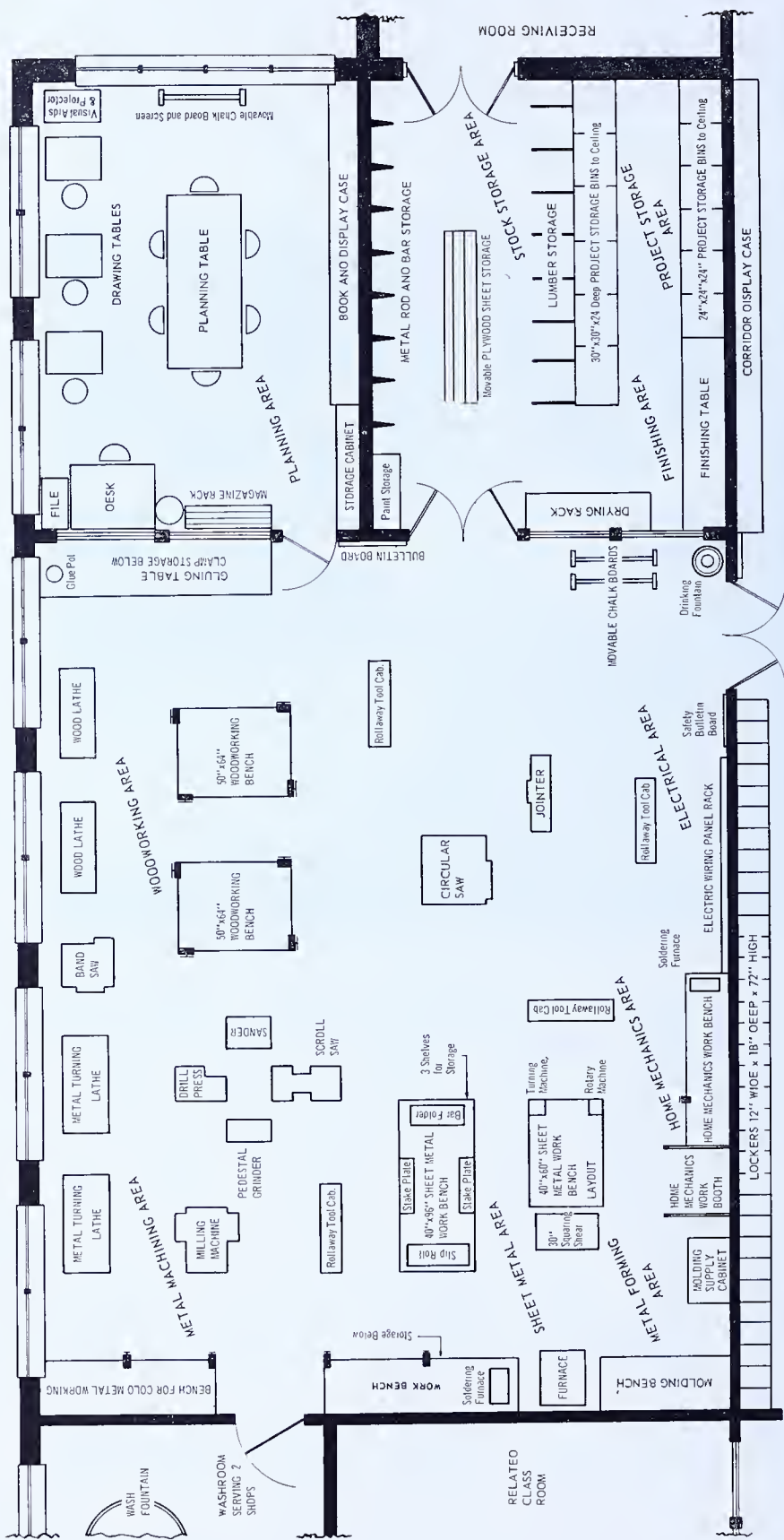


THE COMPREHENSIVE GENERAL SHOP LAYOUT shown on page 42 pictures the following activities combined with the Sheet Metal area:

1. Planning
2. Metal Machining
3. Metal Forming
4. Woodworking
5. Electrical
6. Home Mechanics

Other supplementary bulletins in this series feature room plans for Sheet Metal taught with other subject areas.

Over-all size of the entire area is 32' x 62', or almost 2,000 square feet. The shop area is 32' x 40½'; Planning Area, 15' x 20½'; and the Storage and Finishing Area combination is 16½' x 20½'.



CORRIDOR

TO VOCATIONAL-
INDUSTRIAL SHOP

Equipment shown in the Sheet Metal Area includes the following (see lower left of the plan on page 42):

1. Sheet metal work bench, 40" x 96", with slip roll, bar folder, and stake plates.
2. Work bench for soldering furnace and two vises, with storage below.
3. One 30" squaring shear.
4. One sheet metal layout bench, 40" x 60", with turning machines.
5. One rollaway tool cabinet.

As shown in this plan, materials may be brought directly into the Stock Storage Area from the common receiving room of the school building. The Storage Area includes the Finishing Area and project storage bins.

A common washroom serves two shops: the Industrial Arts Area and a vocational or agriculture shop. A related classroom, to serve the vocational or agriculture shop, is pictured between the two areas.

